A qualitative analysis of the effect of wholistic-analytic cognitive style dimension on the cultural heritage game playing

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Abstract—Retrieving, recalling, processing, organising and storing information are integral parts of the human information seeking process and many socio-cognitive theories suggest that the approach of the seekers is closely related to their cognitive processing styles and abilities. The aim of this study is to investigate the impact of wholistic-analytic cognitive style to players' behaviour in the context of a cultural heritage game. Thirty two people participated in the study and qualitative data were collected and analysed in order to study the aforementioned effects. Analysis of results revealed differences in behavioural patterns between wholists and analysts. Findings of this study are expected to be used by game designers and practitioners aiming to offer bootstrapped gaming experiences based on individual differences in information processing.

I. INTRODUCTION

In the evolutionary technological era of ubiquitous computing, virtual and augmented reality, gaming has been one of the most fertile fields for creating immersive experiences. In the cultural heritage domain, many games have been developed aiming to provide immersive experiences and ensure a certain level of learning. In such cases where gaming has the dual purpose of entertainment and learning, research on how individuals develop strategies and adopt behaviours, while they are engaged in game-play, can help designers better understand users and thus use the acquired knowledge for developing more player centred games. Hence, in this paper we investigate whether certain individuals develop different gameplay strategies, whether behavioural patterns exist and whether they are accredited to individual approaches of retrieving, storing, processing and recalling information related to a particular game play context.

A. Individual cognitive differences

The present work is primarily focused on the individual differences based on the different high level cognitive factors, i.e. styles, and abilities [1], [2], [3]. According to these theories, each individual has a preferred way of information seeking, representation, process and retrieval throughout the

sensemaking process, and this way is inseparably linked to their individual cognitive skills and abilities, such as mental focus or information process speed. Grouping the individual cognitive skills and abilities, high level cognitive processes are formed, which describe and interpret the differences observed in individuals' information sensemaking process [1], [2], [3]. These high level cognitive processes are called cognitive styles, and number of them have been developed and studied over the years such as cognitive style analysis [4], [5], cognitive style index [6], Kirton adaptation-innovation inventory [2] and field dependants/independents theory [3].

For the purposes of this study, the wholistic-analytic cognitive styles were elicited by exploiting Riding's Cognitive Style Analysis test (CSA) [4]. This is a two-dimensional cognitive style measurement tool, which measures individuals' ratios in two orthogonal dimensions: wholistic-analytic and verbalimagery. For the context of this study, only the wholisticanalytic dimension is examined.

The wholistic-analytic dimension indicates the way the individuals follow to organise and structure information. Individuals characterised as wholists retain a more holistic and overall view of information when processing it, organising it and structuring it. On the other hand, individuals characterised as Analysts de-construct information into smaller components in order to process it and organise it [4].

The theory behind the wholistic-analytic dimension is closely related with the classification of individuals as field dependants or independents [3]. However, Cognitive Style Analysis differs from the traditional assessment methods such as the group embedded figures test, as it positively measures the wholistic tendency, compares individuals' performance on the two halves of the continuum and provides a more accurate time mechanism, as it is computer based [4]. Moreover, it is objectively measured, it provides independent cognitive style dimensions, it distinguishes personality traits and intelligence, it is related to observed behavioural patterns and has physiological correlates [7], [8], [9]. However, a number of concerns has been raised by the research community, arguing about the reliability, stability and validity of the Cognitive Style Analysis tool [10], [11], [12], [13]. The major concern is that this tool does not measure the individuals' cognitive style, but a mix of their cognitive styles and abilities [14], as the calculated ratio is based on the ability of the respondents to answer fast. Nonetheless, a number of refinement guidelines have been developed [12], [13] and adopted in the present work.

B. Related Work

Both low-level cognitive factors such as working memory load, selective attention, visual perception, reasoning, etc., and high-level human factors, such as cognitive styles, have an impact on the gamers' playing experience, behaviour and their performance against their objectives [15], [16], [17], [18]. Players' individual cognitive skills and abilities are used to solve problems and puzzles during the game, overcome challenges and interact with the game mechanisms and other players, in order to progress and achieve their objectives.

Regarding the effect of the wholistic-analytic dimension of the Cognitive Style Analysis instrument on gaming behaviour a number of studies have shown that there are differences between wholists and analysts [17], [18], [19], [20], [21].

C. Motivation

Gaming objectives in the cultural heritage context have an inherent multidimensional nature including both entertainment and learning goals and have drawn many researchers to study the field throughout the years. Apart from familiarisation and usage of cutting edge technologies, understanding how users interact in such contexts is a challenge that researchers have to overcome. In this paper, we turn to socio-cognitive theories in order to analyse players' interaction behaviour in the context of a cultural heritage game. In particular, this work focuses on two groups of people based on two different cognitive styles, wholists and analysts, and investigates their game playing approach in a cultural heritage environment.

Therefore, the main research question raised and investigated in this work is: are there differences regarding the game playing behaviour among players with different cognitive styles? To examine the aforementioned research question Time Explorer was used, an online video game provided by British Museum. The main reasons leaded to the selection of Time Explorer are that it is a cultural heritage game which is well established, online accessible and it integrates multiple gaming mechanisms adopting various game genres such as action, adventure and problem solving. The players of Time Explorer travel back in time to explore and discover the traditions of glorious ancient civilisations, such as Ancient Egypt, Imperial China, Aztec and Roman Empire.

II. METHOD

A. Study Procedure

The study consisted of five stages: a) participants' recruitment; b) collect demographic data for each participant; c) participants take the computerised Cognitive Style Analysis test; d) game playing; e) semi-structured interviews with participants. At first, the recruitment of the participants took place. A set of minimum requirements were set and should all be met by the participants. They were:

- The participants should be active and experienced online gamers. In particular, they should be actively engaged with online gaming activities for more than twelve hours per week;
- The participants should not have played the Time Explorer game before;
- The participants should not have taken the Cognitive Style Analysis test before.

After the recruitment, the main stage of the study followed which took place in the HCI Laboratory of the Human Computer Interaction Group of the University of Patras. Due to the number of the recruited participants (thirty two participants in total), and their individual duties and available time, five main study sessions were scheduled, all at times convenient for the participants.

The main study session for each participant lasted no more than sixty minutes. At first, they were asked to complete a short questionnaire providing demographic information, and then they proceeded to the computerised Cognitive Style Analysis sessions, which were facilitated by one member of the research team, and had a total duration of fifteen minutes.

The game session followed and eye tracking, video and screen recording mechanisms were utilised to capture the gaming behaviour and movements of each player. Prior to the main level of the game, an introductory playing phase along with a short tutorial took place, to familiarise the participants with the game mechanisms, environment and controls. Next, the main level of the game took place, where the players had to find and rescue a mystical mosaic mask in Aztec Mexico. The time allocated for this phase was twenty five minutes in total. Each participant was discretely observed by one of the members of the research team. A semi-structured interview followed with the participants, to further investigate their behaviour and incentives during the game. The time allocated for the interview was ten minutes.

Prior to the main study, a pilot study was carried out in order to test the study environment, component and instruments, the overall study flow and the pilot study subjects' playing behaviour, aiming to modify and refine the study if necessary.

B. Game

The game selected for this study was Time Explorer of British Museum, a well-known and multiple award winning game, that requires players to perform several information processing tasks through game-play. Time Explorer has a number of different levels; for the scope of this study the level of the Aztec civilization was selected. The aim of this level was to rescue a mystical mosaic mask. To get it, the players had to overcome challenges, solve problems and find hidden messages and games. Various objects are hidden in the game, which could help the players on their journey. Knowledge artefacts, e.g. bonus facts and objects, were also scattered throughout the game, which would not only provide information about the Aztec civilization to the players, enhancing their knowledge, but they could also increase their score. In particular, the formula that calculates the final game score is formed by three main parameters: the total time required by a player to complete the level, and the number of hidden objects the player discovered and collected.

The Aztec level has five stages, which the user visits in order to rescue the mosaic mask, as it is seen in Fig. 1. The level starts having the player standing on a sacrificial stone, which provides information about the human sacrifice in Aztec culture. After waiting a short period of time on the stone, the stairs are activated and the player proceeds to the next stage. There are a few objects hidden, providing information about the eagle warriors, a special class of infantry soldier in the Aztec army; Aztec stone sculptures; and wooden spear, one of the most popular Aztec weapons. When examining the stage's stone sculpture, a puzzle appears revealing a map showing a path, an asset that is helpful for the final stage.

Getting some stones from the stone pile, the player increases his weight and he is able to use the stone column and proceed to the third stage. In this stages there are some dangers, e.g. a guard moving around, that the player must avoid in order to be healthy enough to finish the level. Some precious objects and facts are revealed in the stage: a Chimalli, a mosaic ceremonial shield showing a picture of the Aztec universe; a stone owl, which was used when a sacrifice was taken place, as the owl was believed to be the messenger for Mictlantecuhtli, the lord of the underworld; information about the colours used focusing on the significance of turquoise.

Using a lever provided in the third stage, a wooden bridge is built and the player proceeds to the next stage. In this stage the objects and facts reveal information about the use of mirrors in Aztec culture; the naming process; the significance of the day people were born on their future and Tenochtitlan, the capital of the Aztec Empire. In order to proceed to the final stage, the player has to unlock a stone door by answering a question about Aztec warriors, information that was obtained when he was on the second stage.

In the final stage the player reveals an Aztec mosaichandled knife, which is thought to have been used in religious ceremonies. Then he moves to the chest, following a path revealed on the map obtained after solving the stone sculpture puzzle. Finally, the mosaic mask appears; the player gets it and returns it to the priest.

An inventory is available to the player throughout the game, providing information about the each revealed object and fact; player's health, time remaining and points collected. The activities each player could perform while playing are: move, make an action, provide an answer, play a hidden game and view the inventory (menu). In order to move around the level, players use the arrow keys; when they want to make an action, e.g. talk to people, collect items, open door and chests, they



Fig. 1. The Aztec level of Time Explorer.



Fig. 2. Player's inventory.

use the space bar; when they want to answer a question, they press 1, 2 or 3 accordingly; when a hidden game is revealed, they can play it using either the left and right arrow keys ot the mouse; in order to open or close the inventory (menu) they can either press the M key, or use the mouse.

C. Participants

Thirty two participants were recruited to take part in the study during the spring semester of 2016, eight females (25%) and twenty four males (75%). Their ages ranged between eighteen and thirty years old, with a mean age of twenty two years old (SD = 4 years). All participants were experienced video game players, as they stated that they typically play single-player online games more than twelve hours per week. In order to increase the validity of the study, all participants should have the same level of experience regarding the Time Explorer game. Hence, the participants recruited had never played that game before.

D. Instruments

The instruments utilised in the present study included the cognitive style analysis tool, splitting the participants into the wholistic or the wnalytic group, and the tools used to gather and analyse the data qualitatively.

1) Cognitive Style Analysis Tool: To classify the participants as wholists or analysts a computerised version of the Cognitive Style Analysis [4] assessment tool was used, taking into consideration the guidelines proposed by Rezai and Katz [13]. The measurement test consisted of two subtests. During the first subtest, pairs of complex geometrical figures were displayed and the participants were required to judge whether they are the same or different. During the second subtest, a simple geometrical shape, e.g. a square, and a complex geometrical figure were displayed, and the participants were

 TABLE I

 WHOLISTIC AND ANALYTIC DIMENSION OF PARTICIPANTS.

Group Statistics W/A ratio

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Group	N	Mean	Std. deviation	Std. error mean
Wholist Analytic	15 17	0.9321 1.5927	0.1957 0.3591	0.0505 0.0871

required to indicate whether or not the simple geometrical shape is contained in the complex one. The computer system recorded both the latency of each response and the answer of each participant. Combining both these parameters the wholistic-analytic ratio was calculated, ranged between one and two.

The participants' average performance on the computerised Cognitive Style Analysis was 1.213 (SD = 0.443), distributed normally according to Shapiro-Wilk test (p = 0.174 > 0.05). According to the original work [4], if the wholistic-analytic ratio is less than one, the individual is classified as wholist, and if it is more than one, the individual is classified as analyst. However, a number of studies [12], [13], [22] have shown that the mean wholistic-analytic ratio ranges between 1.20 and 1.28, as it is sensitive to the order in which the matching figure and embedded figure subtests are displayed, and thus the mean wholistic-analytic ratio was adopted as the cut-off ratio for the present study.

Therefore, the cut-off ratio was decided to be 1.213; if the wholistic-analytic ratio is less than 1.213 the participant is classified as wholist, else the participant is classified as analyst. Based on this classification scheme, fifteen participants determined to be wholists and seventeen analysts. It is also important to stress that the frequencies of the participants' wholistic-analytic ratios using the Cognitive Style Analysis assessment tool is comparably similar to ratios measured for different individuals of different demographics by other studies [12], [13], [22].

2) User Observation: In the present study the user observation method was used, which involved a researcher observing study participants as they were playing the Time Explorer game, and taking notes on their activity. Two types of observation could be identified, direct and indirect. On direct observation the researcher is present during the study task, whereas on indirect observation the researcher views each participant using other means, such as video recorder. For the purpose of the current study, direct observation was utilised.

Observational methods introduce a number of strengths such as the capability of researchers to view the behaviour of the users in context. They could also focus on specific areas of interest, capturing behavioural patterns that would otherwise not recorded or noticed. However, the behaviour of the study participants might be altered due to observer presence. Therefore, strong interpersonal skills are required by the observer, in order to have an effective and efficient cooperation with the study participants.

3) Interviews: A frequently used methodology for evaluating systems is the interview. Depending on the aim and the objective of the evaluation study, there are several approaches that could be followed [23], [24]; however, the interviews fall into three major categories: unstructured interviews, semi-structured interviews and structured interviews.

For this study, semi-structured interviewing was utilised, allowing the research team to cover a predefined set of questions, but they could also ask additional questions to uncover valuable information that may arise, adding flexibility to the method [25]. Semi-structured interviews have a great impact on the data collection process, as they provide a thorough examination of the research topics, in-depth information achieved by follow-up questions, understanding of the participants' way of thinking, feelings, attitudes and motives behind a decision they made while playing [26]. All the responses of the participants were recorded and analysed.

III. STUDY ANALYSIS

Analysts spent more time moving around the level and interacting with various game elements, such as hidden objects or mysterious people. They were trying to make sense of each level situation by discovering and utilising small components which could lead them to view the overall picture of the game and guide them to the final level in order to finish the game. On the other hand, wholists discovered less items, solved less in-game puzzles and interacted with less game elements. Therefore, they needed less time to proceed to the final level. The aforementioned finding apply also on the total number of interactions, as analysts interacted with game assets e.g. talk to people or open doors, more often than wholists.

In order to complete the game, the players had to answer a question displayed when trying to acquire the Aztec mask on the final stage of level. Despite the fact that the correct answer had be given by the Aztec warrior of the second stage, none of the wholists went back in order to look for it. Instead, they preferred to guess the correct answer, as no penalty points were given for wrong guesses. On the other hand thirteen of the seventeen participants stated that they were aware of the right answer, as they had identified the related hidden object, whereas the remaining four participants guessed the answer, either because it was the most plausible one, or because they could not recall the information provided by the Aztec warrior.

"... I knew nothing about Aztec warriors, so I picked a random answer. I was lucky with my second attempt ..." by participant 9 (wholist).

"... I had no idea, but it was obvious I guess ..." by participant 18 (wholist).

"... Eagles and Jaguars of course; the warrior had already told me about it ..." by participant 29 (analyst).

"... I was almost sure, but I checked the inventory in order not to lose ..." by participant 25 (analyst). The Aztec warrior was a game asset on the second stage of the game level, who provided the players with information about Aztec warriors, which was critical for the final riddle of the game. That information was given to the players only when they were interacting with the Aztec warrior. A noteworthy fact is that wholists did not observed the Aztec warrior through the gameplay, while analysts paid close attention to him.

Regarding the overall playing behaviour, wholists could find the final stage of the level very quickly, during their first steps in the game, and having in mind that they should get there the soonest, they did not pay attention to details, that could be helpful to finish the game without guessing. That is something that was reflected both on real time observation and the interviews. In particular, when they were asked about their strategy, eleven wholists answered that they knew were the mask was hidden, and thus their aim was to get there the soonest and rescue it, in order to complete the game and achieve a high score. When they were asked about the hidden objects, nine of them stated that they were not sure what they were and where they could look for them.

"... I did not know where should I search in order to find any helpful information. Anyway, I don't even know if it was really helpful. I mean, I knew where the mask was; how could an object help me? ..." by participant 31 (wholist).

An interesting fact is that the only objects that were revealed and collected by all wholists were the ones that were prerequisite to go to the next level stages, e.g. a pile of rocks used to increase their weight to lower the stone column and proceed to the third stage. Even in such situations though, they did not paid much attention on the provided information about the Aztec civilisation, as it was revealed through interviews.

"... I had to increase my weight in order to continue, so I collected some rocks ... I guess rocks were the main construction material for Aztecs, but I'm not sure ..." by participant 9 (wholist).

On the contrary, analysts spent more time investigating each stage, despite the fact that they stated that they knew from the very beginning of the game where the mosaic mask is; a statement that is in line with the statement of wholists. However, the two groups had different strategies and behavioural patterns. Contrary to wholists, analysts tended to discover and collect more hidden items, as they could not only help them throughout the game (stated by fourteen analysts), but they could also familiarize with the Aztec civilisation (stated by ten analysts).

"... I had no idea how to climb the stairs, so I stood on the circle, and a popup displayed providing information about sacrifices ... I don't know much about Aztecs, and that was a fact I was not aware of ... The stones helped me to go down, but they also helped me understand that Aztecs were using them a lot when building ..." by participant 21 (analyst).

"... I knew very little about Aztecs ... They seem to had an interesting army structure ... I will definetely look for more information about Eagle and Jaguar warriors ..." by participant 18 (analyst).

However, that had an impact on the total time needed to complete the game, something that did not affect them on the overall playing behaviour, as they could earn points through the objects they were gathering (stated by twelve analysts, whereas the remaining five were not caring about the overall time).

"... When I opened the menu, I saw that I had earned some knowledge points, so I guessed that each time I was discovering a treasure I was earning some points; so, no, I did not care about time ..." by participant 19 (analyst).

IV. DISCUSSION

Differences between wholists and analysts were measured and observed qualitatively in regards to the game playing behaviour. In particular, the two groups followed different approaches in order to complete their tasks. Wholists tended to seek information in a timely manner and with relatively few actions. On the other hand, analysts found it difficult to discern relevant information from the irrelevant, and thus they tended to spend more time when seeking, processing and structure information, a finding that is in line with the literature [27], [28]. Regarding the in-game riddles and puzzles, wholists made guesses in order to overcome the challenges, confirming their intuitive and intrinsic nature [3], [4], [9], while analysts tried to find cues on how they should proceed to the next stages of the game level, based on their analytical information processing style [4], [9].

Having a more detailed view of the objects they had collected and the number of the items missing, the analysts spent more time looking for the missing objects, and eventually they interacted with more game assets than wholists. Being less attentive to the details and having difficulties in detecting them [4], [7], [8], wholists were anticipated to discover less items. On the other hand, analysts preferred to de-construct provided information into small and simple components, in order to analyse and deeply understand a given situation [4], [8], [13]. Hence, they found more items, some helping them to finish the game and other helping them to learn more about Aztec civilisation.

The strategy followed by analysts resulted on discovering more items and receiving more information about Aztec civilisation than wholists. That could have an effect on the learning outcome of the game, and thus derailing the main purpose of the game designers, i.e. "deliver a number of key learning outcomes in a fun and memorable way", as it is stated on their official website ¹. Therefore, it would worth to study further the effect of socio-cognitive theories on game playing, in order not to design games that unintentionally favour a specific group.

At this point, it should be mentioned that the game was simple and no sophisticated actions required or complex problems had to be solved in order for the participants to proceed to next in-game objectives. Hence, the low complexity had an impact on the number of items collected by wholists, as they could finish the game by guessing the answers to riddles. Therefore, they were focused on the external objective, i.e. discover and rescue the Aztec mosaic mask, which was placed on an obvious spot allowing them to proceed more quickly.

V. CONCLUSION

The aim of the study was to investigate the effect of the wholistic-analytic cognitive style dimension on the cultural heritage game playing, based on qualitative methods including subject observation and interviews. The study analysis revealed that the two groups followed different approaches in order to complete their tasks. Wholists tended to seek information in a timely manner and with relatively few actions. On the other hand, analysts tended to spend more time when seeking, processing and structuring information. However, analysts interacted with various game assets were significantly more frequently than wholists.

Regarding the validity of the study, a significant limitation is its limited number of participants and their non-varying profiles, as they were all young undergraduate or postgraduate students. However, the distribution of the collected data is normal, reflecting the general public distribution, regarding the wholistic-analytic ratio (Sapiro-Wilk test: n = 32, mean = 1.213, sd = 0.443, p = 0.174 > 0.05). Taking into consideration that the high level cognitive styles, such as wholistic and analytic, rarely change throughout an adult life, it is anticipated that the observed main effects of the present study would apply to other age groups, e.g. 30-40, as well.

An additional limitation is that only one game was examined, which had never been played by the participants. Despite the fact that Time Explorer is based on a variety of game mechanisms and features, it would be worth to examine the effect of the wholistic-analytic cognitive style dimension on different games and participants of varying level of experience. Therefore, similar research attempts are required in order to acquire a deeper understanding about the effects of human cognitive factors and styles on players' behaviour in cultural heritage games, and thus, increase the external validity of this research.

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